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Department of Agriculture

Agricultural Research Service

June 1994

# Agricultural Research

**Wind Power  
Returns With  
A New Twist**  
(page 4)



## ***Facing the Wind***

It used to be that only western farmers expressed much interest in harnessing wind power. But ARS scientists have begun to field inquiries from cattle operations east of the Mississippi.

The Easterners, anxious to reduce the possibility of manure contamination of streams, are considering changes in their cattle watering practices. And word has trickled eastward that wind and solar power are viable ways to pump from underground water sources.

Meanwhile, in Bushland, Texas, the wind energy team is expanding its horizons. Led by R. Nolan Clark, the researchers are looking beyond the time-honored application for wind power—pumping water. They're also exploring the potential for wind to play a part in meeting other energy needs—like providing heat to farm buildings and homes.

W. Lamar Harris, the ARS National Program Leader for Engineering/Energy, says that Clark's wind energy team is an important part of the agency's energy program.

"We're very fortunate that Clark has convinced DOE [the U.S. Department of Energy] to sponsor much of this work," Harris says. "It's a good program that has been recognized in the agency and by industry and DOE."

One of the problems associated with wind power is, of course, its unpredictability; how can you be sure it will be there, in the right force,

when needed? To improve the reliability of renewable energies, Clark is testing several hybrid systems such as wind-solar power and vegetable-based fuels for operating engine-powered generators to produce electricity when the wind is not blowing.

But while the Bushland scientists work to harness wind energy for human use, fellow researchers stand guard against its destructiveness. Wind tunnels in Manhattan, Kansas, simulate the ruinous force of winds moving at rates that can exceed the automobile speed limit on any road in this country.

Loaded up with small particles, high-velocity winds can literally sandblast young crop plants to death. It's a commonplace scenario, and one that's not confined to the Great Plains—it occurs virtually everywhere in the United States that crops are grown.

And crop losses aren't the only decrease in revenue a farmer with wind erosion problems could face. This is the year in which producers with highly erodible land must deal with wind erosion problems or lose the chance to receive federal funds, under provisions of the 1985 Farm Bill.

Municipalities have a bit more time, but they too face the prospect of losing federal aid—for highway construction—if they do not comply with provisions of the federal Clean Air Act of 1990.

Eighty-three areas in the United States have been identified by the

U.S. Environmental Protection Agency (EPA) as violators of the air quality standard for particulate matter. And it's possible that some of this fine, breathable-particle dust drifts into municipalities from farmland upwind.

ARS is working with EPA to find out whether agriculture is a significant contributor to air pollution. The thought of air quality monitors circling farms as though they were industrial smokestacks is sobering.

In any event, if farmland should be found to be a significant source of "fugitive dust," EPA will look to ARS and other USDA agencies to help farmers find solutions. That's long been the case for reducing wind and water erosion through voluntary conservation plans administered by USDA's Soil Conservation Service.

Addressing the good and bad of wind, all these ARS scientists are concentrating on working with government and industry to provide farmers with finished products that help them run their businesses in an environmentally sound manner.

In the case of the wind energy team, the products are wind turbines and pumps and hybrid systems. For the wind erosion team, it's computer software that helps Soil Conservation Service personnel help farmers keep in compliance with the Farm Bill.

**Don Comis**

Information Staff

Agricultural Research Service

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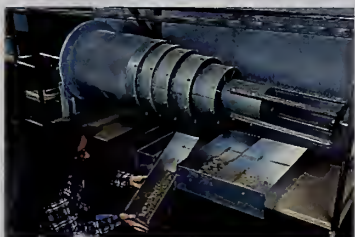
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# Agricultural Research



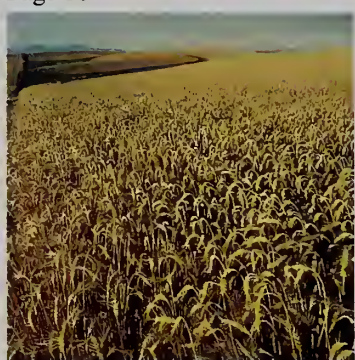
**Cover:** At the USDA-ARS Conservation and Production Research Laboratory in Bushland, Texas, wind turbines generate power for submersible electric water pumps that are far more efficient than traditional windmills (background). (K5474-13)  
Photo by Scott Bauer



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## Wind Power Where You Want It

◀ In a 17-mile-per-hour wind—average for this site—the wind turbine (background) can pump about three times more water than the multiblade windmill. (K5112-17)

▶ A windmill continues to pump water for livestock long after the farmstead has been abandoned for the conveniences of town living. (K5466-1)

When you have a ranch the size of many in Texas—several thousand acres with hardly a stream—you have to install a lot of wells if you want to get all your grass eaten evenly.

After all, a cow won't go too far from water in the dry Southwest—in fact, a half to three-quarters of a mile is her limit, no matter how good the grass looks on the other side. She won't eat grass without enough water nearby to supply her required 10 to 13 gallons a day.

Ranchers pump water from wells into open galvanized tanks for their cattle. Several extra gallons have to be pumped to make sure a cow's water doesn't evaporate under the hot sun before she gets to drink her share. To be on the safe side, ranchers normally maintain a 5-day supply of water in the tanks in case of pump failure.

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Engineers Nolan Clark (right) and Ronald Davis compare new airfoil designs constructed of wood laminates or fiberglass to older ones constructed of metal. (K5467-19)

The scarcity of natural water supplies caused even the buffalo of long ago to avoid the open plains in drought years. Their migrations followed the river systems.

But what the Great Plains region lacks in water it makes up for in wind. Small windmills that harness this energy to pump water from wells were key to opening the Great Plains to ranching in the 1870's. These multi-bladed steel windmills dot the Great Plains and have become a symbol of the West.

The dependence on windmills for livestock water diminished in the mid-1950's when USDA's Rural Electric Administration (REA) began supplying dependable electricity to rural areas. Since then the number of windmills has declined steadily because electric motor-driven pumps require less maintenance and supply water even when the wind doesn't blow.



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But new developments promise a return to wind power, says R. Nolan Clark. He is director of the USDA-ARS Conservation and Production Research Laboratory located near Bushland, Texas.

Clark leads a wind energy research team of two other engineers and two technicians that has worked in cooperation with the U.S. Department of Energy and West Texas A&M University's Alternative Energy Institute since the 1970's energy crisis.

The Energy Department delegates technical supervision jointly to Sandia National Laboratories of Albuquerque, New Mexico, and the National Renewable Energy Laboratory of Golden, Colorado (formerly known as the Solar Energy Research Institute).

The economics now favor alternative power: New electrical transmission lines are anything but cheap, with in-

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To maintain solar conversion efficiency, research assistant Diana Badillo cleans panels once a month. (K5115-2)

### The Conservation and Production Research Laboratory

The wind energy research team develops and tests wind turbines for a variety of uses, from irrigation to supplemental heating of homes and barns and automated feeding and milking in dairy barns.

Examples of the team's research:

- Redesigning wind turbines to stabilize variable power output and increase efficiency.
- Developing wind/hybrid electrical generating systems for rural communities and large farms.
- Developing and testing new airfoil blade designs and new pump designs for increasing water pumped by windmills.
- Generally improving turbine efficiencies to make commercial models more competitive, both in costs—including repair and maintenance—and energy production.

stallation costs of \$25,000 a mile. Even electric co-ops and utilities have given up on the idea of expanding the network of "hard-wired" well pumps. They've found that revenue isn't enough to cover costs of maintaining lines on open range.

### The New Look

Today's wind power machines, called wind turbines, look nothing like conventional windmills. They have long and sleek aerodynamic blades—and only two or three of them at that.

"Wind turbines allow us to use electric submersible pump designs that are far more efficient than the piston pumps used by traditional windmills," Clark says.

When you walk around the 10-machine wind research farm at Bushland, you see the difference. The old windmills pump water in surges, just like a hand-operated water pump. The new pumps, powered by wind turbines, lift water from the well in a continual stream.

Clark is pleased to note that three companies are now manufacturing an improved controller designed by the Bushland wind energy team. The controller senses electrical frequency and functions as an automatic on/off switch for stand-alone pumps.

The new wind turbines offer farmers and ranchers the chance to produce their own electricity in the middle of their fields. The electricity flows along a short length of cable from a generator to operate small, submersible pumps.

At 17 mph—the average speed of wind blowing against turbine blades on 60-foot-high towers in the Great Plains—the wind packs a potential wallop of 100 watts for every square foot of turbine blade area that it blows against. A livestock water pump can be operated by a 12-foot-



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▲ Natural indicators—such as this distorted tree—are used to determine good wind energy sites for pumping livestock water and powering other farm electrical needs. (K5469-7)

◀ Agricultural engineer Nolan Clark (left) shows engineering technician Michael Bayles a rotor assembly of a newly designed machine for pumping water. Working models of several wind harnessing systems are tested by the ARS wind energy research team. (K5465-11)

► Water for these horses is provided by a 100-watt, solar-powered pump that lifts water from a depth of 90 feet. (K5113-2)

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diameter turbine blade that produces about 2,100 watts per hour.

For the past year, Clark has been comparing a wind turbine with a solar pump and a conventional 16-blade windmill. He found that the turbine pumps 6 to 8 gallons a minute, compared to 2 to 3 gallons pumped by the windmill. Yet the wind turbine system costs just \$500 more than the \$6,000 for a windmill.

While the solar pump cost only \$3,500, it pumped much less—a gallon to a gallon and a half a minute. Clark is beginning a study to evaluate the possibilities of combining solar with wind power.

Clark believes that the new technology and improved cost comparisons when combined with the aging of traditional windmills—many of them 40 to 60 years old—have opened a window of opportunity for wind turbines.

That point came home to him 2 years ago when he sponsored a workshop on remote water-pumping systems in Amarillo, Texas. He expected about 35 or so farmers and ranchers; instead 200 showed up.

This level of interest led Clark to refocus his windmill research from large wind turbines that operate irrigation systems to smaller machines for pumping livestock water.

Clark says that fears of state legislation outlawing the practice of watering cattle from streams and lakes has even prompted interest from farmers and ranchers in the East.

He is getting calls about turbine-operated pumps from farmers and ranchers, pump dealers, electric utilities, and government agencies throughout the country.—By **Don Comis**, ARS.

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# Stemming Wind Erosion

**E**ver since the Dust Bowl smothered 20 counties in the northern Texas Panhandle, Oklahoma, Kansas, and Colorado in the mid-1930's, the U.S. Department of Agriculture has been searching for ways to help farmers keep the dust down. Farmers have been largely successful, and the Dust Bowl

is not likely to return. But mini-dust storms are a regular occurrence when the wind blows across the Great Plains, as well as in scattered locations throughout the country.

These dust storms carry away valuable topsoil along with soil nutrients needed for high crop yields. And they sandblast seedlings to death.

The fine particles that blow the farthest may contribute to air pollution, potentially causing human health problems. [See box on page 12.]

For more than three decades, Donald Fryrear has tracked dust storms for USDA's Agricultural Research Service. He grew up with the Dust Bowl. As a



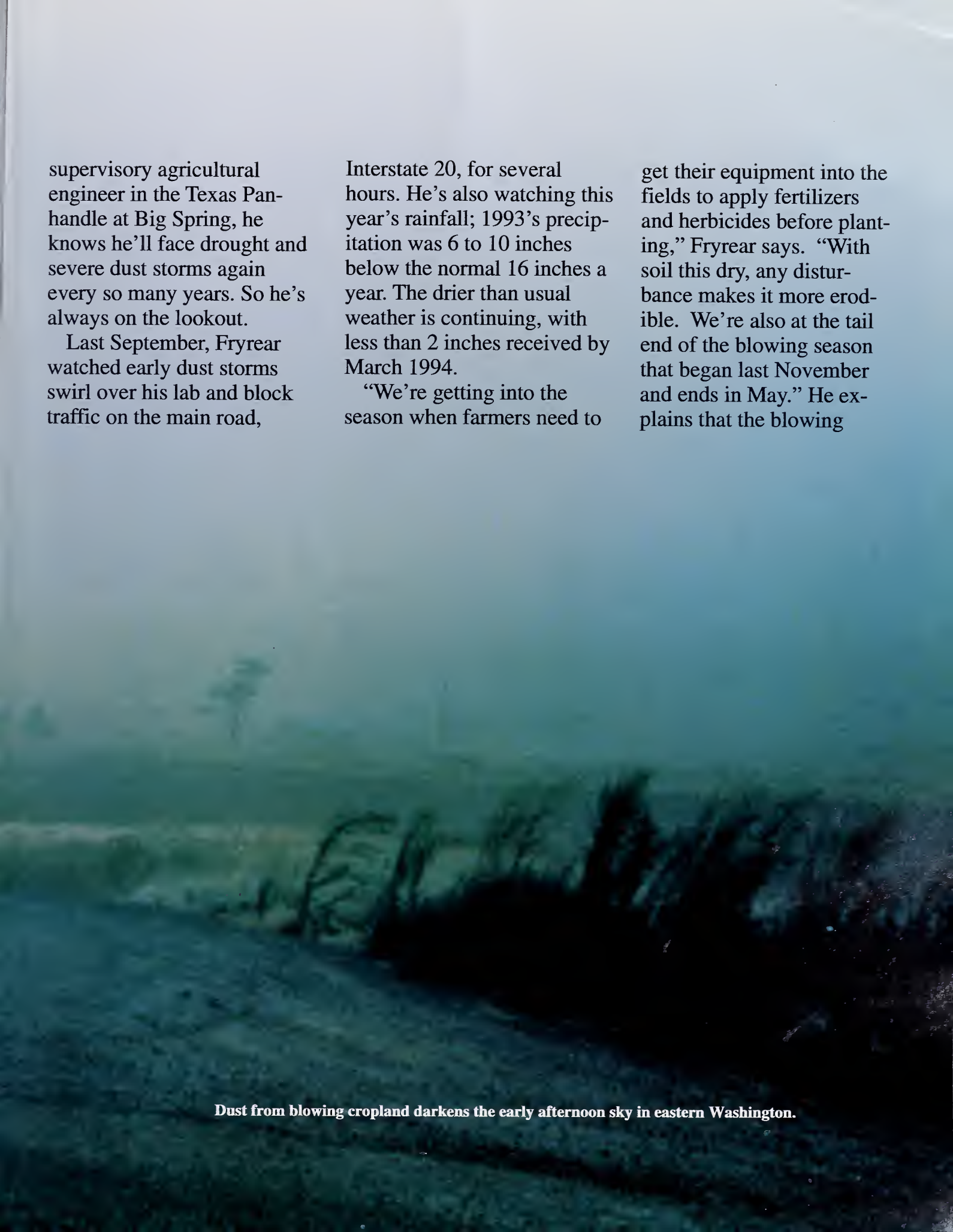
supervisory agricultural engineer in the Texas Panhandle at Big Spring, he knows he'll face drought and severe dust storms again every so many years. So he's always on the lookout.

Last September, Fryrear watched early dust storms swirl over his lab and block traffic on the main road,

Interstate 20, for several hours. He's also watching this year's rainfall; 1993's precipitation was 6 to 10 inches below the normal 16 inches a year. The drier than usual weather is continuing, with less than 2 inches received by March 1994.

"We're getting into the season when farmers need to

get their equipment into the fields to apply fertilizers and herbicides before planting," Fryrear says. "With soil this dry, any disturbance makes it more erodible. We're also at the tail end of the blowing season that began last November and ends in May." He explains that the blowing



Dust from blowing cropland darkens the early afternoon sky in eastern Washington.

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In a wind tunnel, technician Brent Schroeder prepares to measure how live plants and straw residue slow windblown soil erosion. (K5096-19)

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season is when winds are typically the strongest.

Fryrear is working on the latest tools that farmers and ranchers can use to lessen the damage from these storms. Two of these are new computer programs that model the effects of wind on farm fields. One, known as the Revised Wind Erosion Equation (RWEQ), can simulate soil movement from wind for periods of 1 to 15 days. It will replace the Wind Erosion Equation in use since 1965.

Using a weather simulator, the other program, called WEPS, simulates a dust storm in 15-minute intervals and updates field surface conditions daily. WEPS stands for Wind Erosion Prediction System.

When the RWEQ program is fully operational, local Soil Conservation Service (SCS) personnel will type in a farmer's information such as planting date, tillage method, and estimated amount of residue left from the previous crop. The model

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◀ Soil scientist Jean Steiner counts the few remaining standing stems in a barley plot that has decomposed during a 12-month fallow period. (K4795-5)

▶ Technician Brent Schroeder measures the force needed to crush these soil clumps to see how well they would resist abrasion during a windstorm. (K5095-1)



considers all these factors and then uses a weather simulator to predict future erosion.

Fryrear coordinates the RWEQ project, working with others across the nation. Lawrence Hagen, an agricultural engineer, leads the ARS Wind Erosion Unit at Manhattan, Kansas, and is coordinator of the WEPS project.

Hagen and his colleagues rely on wind tunnel and field tests to gather data. For example, they have documented the way a 30-mph wind sandblasts seedlings, tearing away cells of newly emerged sorghum, soybeans, and wheat.

Wind damage isn't confined to the western states, either. Fryrear says that farmers in Delaware lose crop plants in 1 of every 4 years on the average. The sandblasting effect causes them to have to replant cantaloupe fields, for example.

RWEQ is being tested by SCS. A final version is scheduled for release

this year. WEPS will be available for widespread use in 1996, according to Hagen.

### **EPA and the Dust-Monitoring Network**

To supply data for the computer models, Fryrear has a network of sampling devices in 14 states, in cooperation with farmers, universities, the Soil Conservation Service, and the Forest Service. Invented by Fryrear, the devices collect dust samples at various heights above the ground, usually up to 3 feet.

Two years ago, Keith Saxton, who is with ARS at Pullman, Washington, joined Fryrear's dust-monitoring network. He uses samplers from the U.S. Environmental Protection Agency (EPA) and Fryrear.

Saxton says that his state has had a drought for the past few years and has the potential for serious erosion. "The below-average rainfall will not grow

enough crops to provide crop residue—stems and other plant remains—needed to protect bare soil.

"Our volcanic soils are very vulnerable to blowing because they have little clay or organic matter to bind them together."

He is gathering data in the Pacific Northwest so that the wind erosion models will be tested on a broader range of soils. Says Saxton, "We are doing the research needed to get a better handle on how fine particles blow away and to find ways to keep them on farm fields."

### **Incoming Dust**

Saxton says that as cities struggle to avoid financial penalties for air quality violations, they are controlling dust from unpaved roads and storage piles and other fine-particle emissions from smoke. But they are also asking about the incoming dust from upwind rural areas.



Both weather and tillage affect the number and size of clumps in crop soils. Here, student employee Cheryle Nowlin uses a rotary sieve to measure changes in soil samples. (K5095-18)

## Fugitive Dust

Very fine dust contributes to health problems.

Recent studies show that there may be as many as 60,000 premature deaths a year from exposure to fine particles.

These particles can come from many sources, including dust from roads and storage piles; smoke from factories, fireplaces, and woodstoves; automobile exhaust; and in some cases, blowing soil from distant farm fields.

In air quality terms, it's known as PM-10—particulate matter 10 micrometers or less in diameter. Small enough to be drawn into the lungs,

PM-10 affects mostly children, the elderly, and those with influenza, lung or heart disease, or asthma.

Since one source of dust is from blowing soil, ARS engineers Lawrence Hagen, Donald Fryrear, and Keith Saxton have begun a cooperative project with the U.S. Environmental Protection Agency to develop a computer program module to predict the occurrence of very fine dust emissions from farmland.

Robin Dunkins, with U.S. Environmental Protection Agency's Office of Air Quality Planning and Standards in Durham, North Carolina, says that "fugitive dust" from farmland is one possible source of PM-10 pollution.

She recently placed PM-10 samplers at Big Spring, Texas, alongside the larger particle samplers designed by Fryrear. "We want to see if there is a correlation between wind erosion and PM-10 particles suspended in the air," Dunkins says. "If there is, then we can use wind erosion models to predict PM-10 emissions from an open area or field."

Dunkins stresses that EPA is still in the stage of determining to what extent farmland contributes to the fine dust problem. If there is a problem, Dunkins says EPA would "look to USDA for the best practices that farmers can use to prevent PM-10 emissions."



The percentage of soil protected by crop residue will be determined using photographs taken by student employee Melinda Holmes. (K4795-9)

The current EPA standard for fine dust is a maximum of 150 micrograms per cubic meter of air over a 24-hour period, not to be exceeded more than once per year, and 50 micrograms per cubic meter for the annual standard.

To date, EPA has designated 83 areas of the country as "moderate non-attainment" areas for violating this standard. Of these, five have been reclassified as "serious non-attainment" areas because they will not be able to meet the PM-10 standard by the end of this year. States that fail to develop or implement plans to meet the PM-10 standard could eventually face the loss of highway funds.—**Don Comis, ARS.**

"We're talking now about the off-site effects of wind erosion," Saxton says, "just as we've been talking about off-site effects of water erosion."

Saxton does intense wind erosion field studies, as well as indoor wind tunnel studies at his lab.

Fryrear measured an annual average of 72 tons of blowing soil per acre for the 3 years he sampled farmland at Crown Point, Indiana, 60 miles southeast of Chicago. This is more than 14 times the erosion that is considered acceptable.

The original Wind Erosion Equation indicated that the soils on this farmland were not susceptible to wind erosion. The equation failed so badly in this case because it tried to extrapolate from climate data of the central Great Plains, where the average annual rainfall is less than 25 inches, to places with almost twice that rainfall. It overestimated the length of time soils would be protected from blowing because they were wet.

"But farmers there have the wind and soils that can cause major problems if they don't keep the surface covered with crops. They have 45 inches of rain, so there's no problem growing cover crops. If they neglect to do it, they could have serious wind erosion," Fryrear says.

At Big Spring, on a field intentionally left bare, they've measured 175 tons of soil blown per acre during the November-through-May blowing season for the Great Plains. There was almost no erosion on neighboring farm fields on which soil was protected by tillage and plant residue.

"We saw that the old WEQ could underestimate erosion, such as at Crown Point, and—at the other end of the spectrum—we've seen that it overestimates erosion on the Texas Panhandle, Fryrear says.

Eddy Spurgin, the Soil Conservation Service (SCS) district conservationist at Big Spring, heads one of the field offices due to receive the revised equation. He says he uses the original equation to help farmers bring their soil losses down to 5 tons of soil per acre per year. "That's the 'T,' or tolerance, level for most of our soils here," Spurgin says. "That's the level before you start hurting farmland by removing too much topsoil."

Spurgin says that 55 percent of the 221,288 acres of cropland in his district, Howard County, is highly susceptible to wind erosion. "If you didn't have a wind erosion equation, you wouldn't have a place to start reducing the problem."

He has used the equation on the 998 active conservation plans in his office files, each from a different farmer. The Food Security Act of 1985, commonly known as the Farm Bill, requires all farmers with highly erodible land to have such a plan fully implemented by the end of this year if they want to be eligible for federal assistance of any kind.

### You've Got To Get a Plan

Spurgin describes a typical "transaction": A farmer calls to make an appointment for Spurgin or a member of the SCS staff to visit his fields. Spurgin tours the farmer's land for a half day to a day, depending on the size of the operation. He looks for water- as well as wind-erosion problems and discusses them with the farmer. He tries to get a feel for what the farmer wants to do.

Back at the field office, Spurgin uses WEQ tables in an erosion handbook to assign numerical ratings to the fields he toured. These ratings include climate, amount of plant residue covering the soil surface, degree of soil surface roughness, and amount of land not sheltered by wind barriers.

Spurgin explains that the 1985 Farm Bill requires cotton farmers on highly erodible soils to break up cotton rows every so often with at least four rows of crops planted as windstrips. These crops include grain sorghum, hay, and small grains such as wheat, rye, or oats. The worse the predicted erosion, the shorter the distance between sets of windstrips.

He says that keeping bare soil covered with crops or high amounts of crop residue—stems and other plant remains—is one of the best ways to combat wind or water erosion.

Spurgin uses WEQ to total up the erosive ratings; the higher the rating, the more susceptible to erosion. He also calculates the predicted soil loss from the farmer's fields.

Then Spurgin re-calculates the predicted loss with the addition of the recommended treatments he and the farmer have already discussed. He tries various scenarios until he can get the predicted loss down as close to 5 tons of soil per acre as possible without harming the farmer's profitability.

"In this part of West Texas, we usually recommend a windstrip cropping pattern or rotating high-residue crops on problem fields," he says. "These must be left in place for a year, from spring planting of one year until April 1 of the next year."

"I write up a conservation plan with these recommendations and a schedule for completion," Spurgin says, "and I meet with the farmers and landowners to review the plan. We make sure that this is what the farmers want to do and that it's enough to keep them in compliance with the Farm Bill. Once we're sure, we both sign the plan. Then it goes to a local SCS district board for final approval. We give that plan to the farmer, and we keep a copy in our files. If the farmer calls with questions or wants to make a change, we can review our copy."

Hagen says the plans Spurgin writes are only as good as the equation or computer model used to predict erosion. "With the new models, you should be able to go out into a field and measure erosion levels and get a reasonable match with the computer predictions," he says.

The WEPS technology allows a switch from long-term average annual figures used by empirical models such as WEQ to computer simulations, he says. "For example, by simulating a number of years, we can determine the probability of erosion during each season," Hagen says. The newer models simulate physical processes rather than depend on calculations based on a limited number of past observations of research plots in a few parts of the country, as the WEQ does.

"That's a big step," says Phil Teague, a project manager with the SCS Technology Information Systems Division (TISD) in Fort Collins, Colorado. Teague leads the team that will make the revised WEQ, and later WEPS, available to the SCS field office personnel.

"They're the wave of the future," Hagen says. "We work with SCS and others across a range of disciplines and agencies to 'hand-deliver' technology in a practical package."

Henry Bogusch, the SCS liaison with ARS on the wind erosion computer model projects, says "these new models are Cadillacs compared to the old Wind Erosion Equation." Bogusch is an agronomist based in Fort Worth, Texas.

Fryrear adds that the WEQ was state-of-the art when it first came out. "Improved knowledge through research about wind erosion process has brought us models that are a major improvement.

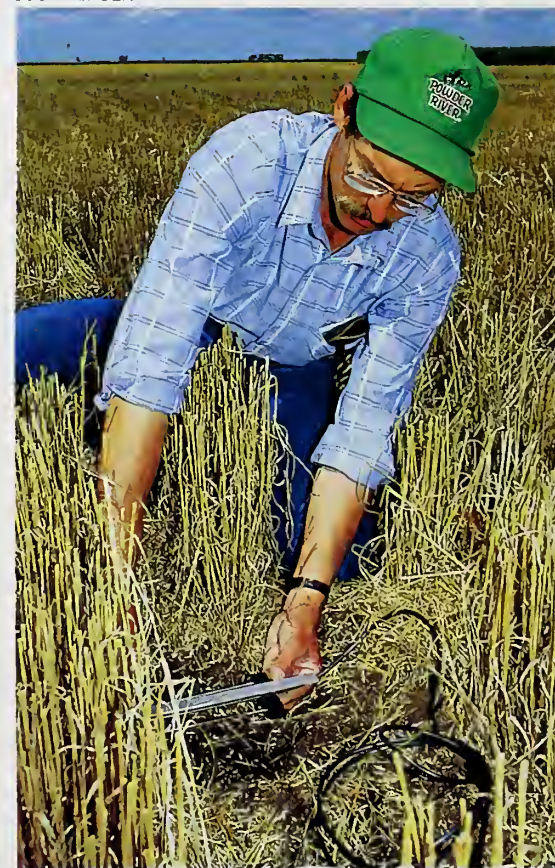
"We have made significant changes in the ways we make our calculations.

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To calculate the amount of crop residue remaining on a field's surface, agricultural engineer Larry Wagner collects samples from a plot and prepares them for weighing. (K5097-2)

SCOTT BAUER



Technician Jim Cresap installs probes to monitor near-surface soil water content in a no-till wheat stubble field. (K4794-9)

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Tillage equipment is tested to determine how it affects soil aggregate size distribution, surface roughness, residue flattening, and residue burial. (K4484-9)

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Student employee Royce Hammonds measures soil water content using a portable computer and cable tester. Water content controls microbial activity and the decomposition rate of crop residues. (K4794-18)

Our techniques for estimating wind erosion regionally and nationally are changing now, to be more accurate and conform to the new models," he says.

"These models will document effects of the improved tillage and residue management techniques that have become so widespread since 1965," Fryrear says. "We have put that information in the revised WEQ; it wasn't in the equation used for the past 30 years. We've also put in the effects of residue lying on the ground, crop stalks standing after the crop is harvested, the protected zone to the lee of a wind barrier, and the effects of plant seedlings growing an ever-larger protective canopy of leaves."

The same type of information is in WEPS, Fryrear says. "With both models, we can simulate how hard rain strikes the soil and how that deteriorates the protective soil roughness."

"We've done our best to put all the research advances of the past three decades into them," Fryrear says.—By **Don Comis**, ARS. **Marcie Gerriets**, formerly with ARS, contributed to this article.

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# Scientists Redesign White Wheat

**N**ew marketing opportunities for U.S. growers are driving ARS scientists to develop new varieties of hard white wheat.

American agriculture currently boasts only one commercial variety of hard white wheat—Klasic, introduced 8 years ago by Northrup King Seed Co. of Minneapolis, Minnesota. Most high-quality bread flour, for either white or whole-wheat bread, is milled from hard red winter or hard red spring wheat.

The main difference between hard red wheat and hard white wheat is

are shaved too close, red specks get in the white flour.

Red wheats have historically been grown in the Great Plains for two main reasons: they resist sprouting from rainy weather during harvest, and the wheats first introduced into the region happened to be red seeded.

Today's red winter wheats trace their origin back to Turkey Red wheat brought by the Mennonites into Kansas in the 1870's.

So for years, ARS researchers in Nebraska working to improve the quality and protein of wheats for the

demand that continues to grow. Australia now leads the world in exports of white wheat used in Asian noodles and specialty flat breads.

"There are many market opportunities for hard white wheats," says Bonnie Fernandez, executive director of the California Wheat Commission. For example, U.S. wheat growers could export hard white wheats for flat bread products in the Middle East, for French bread products in South America, and for Asian noodles in Southeast Asia and Korea. In the domestic market, hard white wheats could be easily blended in all-purpose flours.

Believing that white wheat varieties developed for Nebraska and other Great Plains states could capture a share of these markets, Peterson has begun crossing soft white wheats (from Idaho, Oregon, and Washington) and hard white wheats (from Australia, Kansas, and Montana) with Nebraska hard red wheats. His goal is a hard white wheat suitable for surviving winters and growing conditions in the Great Plains.

"We envision two types of hard white wheats in production to meet marketing opportunities: one for baking breads and another for making Asian noodles," he says.

The ARS wheat breeding program in Lincoln works in close collaboration with University of Nebraska wheat researchers and gets additional support from the Nebraska Wheat Board. Other states interested in developing hard white wheats include California, Colorado, Idaho, Kansas, Montana, North Dakota, Oklahoma, Oregon, South Dakota, and Washington.

"In the United States, we have more demand for white wheat flour than we have wheat," notes Steven Graham, administrator of the Kansas Wheat Commission. An indication of grower interest in white wheat is

SCOTT BAUER



Wheat classes: (left to right) Hard White Spring, Hard Red Spring, Soft White, and Hard Red Winter. (K5451-8)

color genes. Both have similar fiber and protein levels. But whole-grain bread from hard white wheat is less bitter—some say sweeter—than whole-grain bread from hard red wheat. That's because white wheat's outer kernel contains fewer tannins and phenolic compounds.

And because the white kernels can be milled or shaved closer to the bran layer, white wheats also yield more flour than red wheats. If red wheats

domestic market have focused mostly on hard red wheats. "But now we're putting our efforts into improving a different-colored package," says agronomist C. James Peterson.

The U.S. milling and baking industry looks at hard white wheats as an opportunity to develop new bakery products for the domestic market. And in the Asian export market, white wheat is primarily used for noodle products, a consumer

# Lipsticks to Lubricants— Lesquerella

the formation of the American White Wheat Producers Association at Atchison, Kansas. That farmer cooperative is growing three experimental lines of hard white wheat.

Supporting Great Plains wheat growers is ARS wheat geneticist Thomas (Stan) Cox in Manhattan, Kansas. He's been crossing red and white wheats with wild grass relatives to obtain disease-resistant white wheat germplasm for breeders.

On the processing end, ARS researchers in Pullman, Washington, led by Craig F. Morris, are evaluating the milling and baking qualities of experimental lines of hard white wheats developed by breeders at Washington State University, Oregon State University, and the University of Idaho.

Morris says alkaline salts used in making Chinese-style noodles affect the color of the end products. These alkaline salts raise the pH level of the flour causing desirable yellow or undesirable green, gray, or brown colors. The Pullman scientists are also testing the flour for dough-mixing properties and bread quality.—By **Linda Cooke, ARS.**

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*Craig F. Morris is at the USDA-ARS, Wheat Genetics Quality Laboratory, Pullman, WA 99164; phone (509) 335-4055, fax (509) 335-8573.*

*Thomas (Stan) Cox is in the USDA-ARS Plant Science and Entomology Research Unit, Throckmorton Hall, Kansas State University, Manhattan, KS 66506; phone (913) 532-6168, fax (913) 515-5657. ♦*

Lesquerella, a desert shrub that grows in the dry southwestern United States, may be the Cinderella of the New Crops Research program at the USDA's National Center for Agricultural Utilization Research in Peoria, Illinois.

Like Cinderella, lesquerella may be transformed—and its value increased—with new uses in products that range from lipsticks to lubricants for lawnmowers.

Thirty-three years ago, lesquerella was recognized as a source of new

lubricants, coatings, and thickening agents for foods and for crude oil recovery. He found a way to separate gelled gums from seed or from the seed meal after the oil was removed by processing.

"If industry can do the extraction economically, natural gums from lesquerella meal could add to the value of this new crop," says Abbott.

As a thickening agent, lesquerella could eventually be used as widely as xanthan gum, which was discovered by NCAUR researchers in the 1960's. Xanthan gum is made from corn fermentation and can substitute for imported plant gums as a thickening agent in foods.

"Lesquerella gum is stable enough to thicken over a wide range of pH levels or after peroxide bleaching. This is important because its usefulness in cosmetics may require bleaching, and application in oil recovery or as a food thickener would require it to thicken over a wide pH range," says Abbott.

He noted that wet processing with solar drying could be used economically in the Southwest. He has applied for a patent on the process.

Abbott's work is one aspect of the New Crops Research group's effort to develop value-added products from new oilseed crops.—By **Linda Cooke, ARS.**

*Thomas P. Abbott is in the USDA-ARS New Crops Research Unit, National Center for Agricultural Utilization Research, 1815 N. University Street, Peoria, IL 61604; phone (309) 685-4011, fax (309) 681-6524. ♦*

JACK DYKINGA



Oil and gums derived from lesquerella seed are used in cosmetics, lubricants, and even crude oil recovery. (K4690-14)

industrial oils, when NCAUR researchers discovered a new hydroxy fatty acid component in seed oils of several lesquerella species. About then, they also discovered a water-soluble gum in lesquerella seeds.

More recently, ARS chemist Thomas P. Abbott has been studying possible uses for the gums in health and beauty products, plasticizers,

# New Soybeans Open the Planting Window

uell Hinson's new soybeans don't yet have a name, but when they're released a few years from now they may become household words to southern growers.

Hinson, a retired U.S. Department of Agriculture scientist, has bred soybean plants that mature in 130 to 150 days in the South—no matter when they are planted. This overcomes a key problem with previous soybean cultivars: They're very sensitive to day length and won't produce adequate yields if planted too early or too late, Hinson says.

If 1994 field tests confirm preliminary 1992-93 results, the soybeans could be made available to growers by 1996 or 1997.

“We think these new soybeans will give growers across the South some flexibility in planting their crop,” says Hinson, who worked for 38 years as a soybean breeder with USDA’s Agricultural Research Service before retiring last year. “Farmers can plant these soybeans over a 90- to 100-day period from April 1 to early July and still maintain maximum yields of about 40 to 50 bushels an acre.”

Southern growers now have a much narrower window for planting their crop—only 35 to 40 days from about May 10 to mid-June in the Gainesville (Florida) area, where Hinson worked for ARS and is now completing the soybean breeding work at the University of Florida. If farmers try to plant outside that narrow window, yields drop off because the plant's

normal flowering is disrupted and seed production declines.

When the days are long, the soybean plant channels its energy into making leaves, stalks, and other vegetative growth. When the days shorten, the plant senses the reduc-

their juvenile, vegetative growth stage for a longer time. Then, at a fixed time after planting, the plant leaves its juvenile stage, beginning its reproductive period and producing seed.

Because of their day-length sensitivity, soybeans are divided into different maturity groups ranging from Group 000 to X, with 000 suited to the northernmost planting areas and group X to tropical growing areas closest to the equator. Hinson says he has incorporated the long-juvenile trait into germ-plasm in groups V through VIII, making them of most benefit to growers from mid-Tennessee to north Florida.

“We’ve actually gotten good results on the germplasm at Carbondale, Illinois,” he says, “but we feel that most of the new germplasm’s impact would be felt farther south.”

Hinson hasn't decided yet whether to release the new soybeans relatively soon as germplasm—which breeders would further incorporate into current varieties—or as a specific cultivar that farmers could grow without need of further breeding work.

"That decision will depend largely on our field tests in 1994," he says.

Either way, the new soybeans would have advantages over two other varieties that have the long juvenile trait—Padre, developed by Hinson, and Vernal, devel-

tion in sunlight and begins its reproductive period, producing flowers, pods, and seed.

Hinson's new soybeans are what he calls a "long-juvenile type"—meaning that the plants remain in



**Retired ARS agronomist Kuell Hinson inspects long-juvenile type soybean seed being considered for release to breeders or growers. (K5481-17)**

oped by ARS soybean breeder Edgar Hartwig, who has cooperated with Hinson on numerous soybean breeding projects.

Padre, released in 1988, was the first soybean to incorporate the delayed-flowering trait. It's a Group IX soybean, meaning that in the lower Rio Grande Valley of Texas it can be planted from March to early September and still produce an adequate crop. Other Group IX varieties would have a much shorter planting date range at that latitude.

"The advantage of the new soybeans is that they have a much wider latitude range," Hinson says. "Padre is limited to the southern Rio Grande Valley and other lower-latitude locations, whereas the new soybeans can be planted as far north as southern Illinois."

### One Gene for the Juvenile Trait

Hinson began working with the juvenile trait in 1978. Hartwig and colleagues had identified the trait in soybean germplasm that originated in the Orient but came to the United States by way of Peru.

In the mid-1980's, Hinson discovered that the trait was controlled by one gene. Then he began extensive greenhouse and field studies to incorporate the gene into more productive soybean plants.

Before his latest work, Hinson had released a dozen soybean varieties over the years, primarily for the southern United States but also for other subtropical and tropical areas of the world. Many, such as Bragg, released in 1963, were developed to resist root-knot nematodes, which damage plant roots and can reduce yields or even kill the plants in heavy infestations.

This genetic resistance is particularly important now, he notes, since

nematicides are being restricted or banned because of their adverse effects on groundwater. In the late 1960's, Bragg was the most widely grown soybean in the South, accounting for about half the soybeans produced in that region and about 10 percent of the total U.S. acreage.

Later varieties also incorporated resistance to the soybean cyst nematode, which also damages soybean plant roots.

KEITH WELLER



Kuell Hinson (right) and ARS plant physiologist Sherlie West with soybean varieties being studied for their drought resistance. (K5482-9)

Hinson's varieties have had a major impact on soybean production in the southern United States and the Tropics. In 1971, he released a variety called Jupiter that overcame problems associated with short days in tropical areas.

Jupiter takes longer to flower and has enough time to grow so it can produce adequate seed. Jupiter

produced from 34 to 38 bushels an acre in Guyana field tests in 1970-71—much better than varieties adapted for planting farther north.

In Florida, only 8,000 acres of soybeans were planted in 1949; by 1965, 76,000 acres were planted. Florida acreage peaked at about 600,000 acres in 1980-81 and many of those acres were soybeans developed by Hinson and other ARS scientists.

But production in Florida has plummeted since that early 1980's peak to about 50,000 acres today, primarily because of competition from Brazil and Argentina. Other southern states have also seen their soybean acreage drop sharply. But economic factors—such as last year's weather conditions—could prompt increases in southern soybean plantings, Hinson says.

"If economic conditions improve and soybeans are in greater demand, we want to make sure our southern growers have the best soybeans available to them," he adds. "I think these long-juvenile soybeans will provide them with the flexibility to produce a profitable crop."—By Sean Adams, ARS.

*Kuell Hinson, formerly of ARS, is at the University of Florida, Bldg. 164, Box 110840, Gainesville, FL 32611; phone (904) 392-1816, fax (904) 374-5852. ♦*

# Neem Oil Locks Out Spores

Oil extracted from neem seeds covers plant leaves like a raincoat, stopping fungi that cause diseases such as powdery mildew and rust from infecting plants.

Fungal spores are spread by wind and splashing raindrops. "If the spores can't adhere to a leaf, germinate, and penetrate the leaf cells, they can't cause disease," says Jim Locke, an ARS research plant pathologist.

Neem, or margosa, trees are native to India and Burma.

They are related to mahogany, require a frost-free climate, and will grow in West Africa, the Caribbean, Australia, southern Florida, several southwestern states, and Hawaii.

Almost all parts of the versatile plant contain extractable compounds that have been used for centuries in India in personal hygiene products like soap and toothpaste. Seed extract has been used to treat skin diseases, sores, and rheumatism.

Locke says that in numerous tests, a spray of 1-percent neem oil in water "stopped 95 to 100 percent of the powdery mildew on hydrangeas, lilacs, and phlox."

A single spray application was sufficient to protect these ornamentals from infection. Repeated applications at 7- to 14-day intervals as the plants grew provided disease protection without any plant damage.

On plants where mildew had begun to develop, "it was arrested," he says, "providing control comparable to each of three chemical fungicides."

Powdery mildew, which also attacks crepe myrtles and roses, causes leaves to turn white. Preliminary results indicate the oil will arrest and control the fungus that plagues these popular ornamentals, especially in humid areas.

Locke says the oil is the first botanical product to exhibit fungicidal properties. He has been field-testing it for the past 4 years on several greenhouse and nursery crops.

RICHARD NOWITZ



Plant pathologist James Locke displays neem oil, a natural fungicide. (K4053-19)

"We're working now to discover how the neem oil protects the plant from infection," says Locke. Two of the possibilities are that the spores fail to germinate or are unable to penetrate the leaf.

One study involves numerous laboratory tests of roses by Locke's group in the Floral and Nursery Plants Research Unit at the agency's U.S. National Arboretum, Washington, D.C. He says the oil "seems to delay infection by black spot—the number-one disease of roses. As a result, rose bushes lose fewer leaves, compared to untreated, diseased plants."

Locke says this research, begun in cooperation with former ARS entomologist Hiram Larew, also demonstrated that neem oil can reduce damage caused by various pests, including spider mites.

"In preliminary tests, a 2-percent spray of neem seed oil applied directly to spider mite eggs resulted in an 87-percent mortality," he says.

Research at USDA on plant-derived natural pesticides, such as nicotine, dates back to the 1920's.

Beginning in 1975, extraction products from neem seeds were evaluated for their insect-killing properties.

In 1987, ARS researchers demonstrated the systemic activity of a neem seed extract containing azadirachtin against leafmining flies. Larvae that fed on plants grown in azadirachtin-treated soil rarely survived to adulthood. Azadirachtin-based insecticides became the first neem product to be approved by the U.S. Environmental Protection Agency.

Locke says the botanical insecticides, Margosan-O and BioNeem, contain azadirachtin. Unlike neem oil, they have no fungicidal activity.

Under a cooperative research and development agreement with W.R. Grace and Company, Columbia, Maryland, Locke is testing the oil as a fungicide that may be available commercially later this year.—By **Hank Becker**, ARS.

*James C. Locke is in the USDA-ARS Floral and Nursery Plants Research Unit, U.S. National Arboretum, Bldg. 004, 10300 Baltimore Avenue, Beltsville, MD 20705-2350; phone (301) 504-6413, fax (301) 504-5096. ♦*

## Spot-Checking for Successful Aerial Spray

Seeing spots isn't so bad anymore—at least, not for the people whose job is to check the accuracy of farm pesticide applications.

That's because ARS agricultural engineer Eric Franz devised a way to take the tedium out of analyzing spray depositions, the pattern of droplets that shows whether aerial applications of pesticides are landing where they're most needed. Franz, who worked in the ARS Aerial Application Research Unit at College Station, Texas, died in February 1994.

In conventional spray deposition analysis, small water-sensitive cards are placed in a field. The aerial applicator—yesteryear's "crop duster"—flies over the field and sprays, depositing spray droplets across the cards. Every little splotch has to be counted and measured, a chore that can take an hour per card.

Frantz's system, called image analysis, uses a computer and a video camera to count and measure the spots. The water-sensitive cards are still used, and the aerial applicator still does the fly-by.

But after the fly-by, the cards are scanned with the video camera, which is attached to the computer. Using Franz's software, the computer translates the spots to digital information. It can calculate the area of spray coverage, the number of spots in a unit area, and the droplet size.

Poor coverage often means poor control of targeted pests—and wasted pesticides. But simply getting the material to the pest isn't necessarily enough.

In earlier studies, Ivan W. Kirk of the College Station lab demonstrated that droplet size is important in effective pest control. Kirk pinpointed the size of droplet needed for control of certain insects and showed that some insecticides are more effective in larger droplets.

Although Franz's image analysis system is only a research tool as yet, the College Station lab has already cooperated with the National Agricultural Aviation Research and Education Foundation (NAAREF) on a project to demonstrate to aerial applicators how wind, aircraft setup, spray boom length, boom location, altitude, and airspeed can affect droplet size and distribution.

At NAAREF's request, the College Station scientists found a way to use a hand-held scanner to take the place of the video camera. NAAREF subsequently demonstrated that system in workshops throughout the South and in Texas, Arizona, and California. Such equipment would allow a consultant to use Franz's system in the field with a portable computer.—By **Sandy Miller Hays**, ARS.

*For more information, contact Ivan W. Kirk, USDA-ARS Southern Crops Research Laboratory, Room 231, Scoates Hall, Texas A & M University, College Station, TX 77843; phone (409) 260-9364, fax (409) 260-9367. ♦*

## Computer Custom-Designs Flumes

A new computer program is now available to help engineers design better flumes—flow-measuring devices that help irrigators reduce water use and runoff and improve crop yields.

Water that flows off fields can remove agricultural chemicals, threatening purity of both surface and underground water supplies.

"Municipal and industrial water users should find the program useful," says ARS' Albert J. Clemmens, a hydraulic engineer in Phoenix, Arizona. "They need accurate flumes to measure amounts of water diverted from streams and wastewater flowing in sewers."

Called FLUME 3.0, this computer program custom-designs site-specific flumes for any open channel, waterway, or stream. It takes the guesswork out of designing long-throated flow-measuring flumes and their related broad-crested weirs.

Before its development, engineers either had to select from existing shapes and sizes of flumes or, for long-throated flumes, design one through trial and error using a computer program originally developed in the early 1980's for calibrating flumes. Too frequently, the limitations of these designs were not apparent until after the structures were built and operated over a full range of field conditions.

In contrast to the earlier program, FLUME 3.0 is simple to use and menu driven, prompting and helping as the user enters relevant data, such as channel conditions upstream and downstream from the proposed site. It allows the design of devices having different cross-sectional shapes, such as an approach channel made from a circular section of steel pipe, while the flume crest could be shaped as a formed-concrete trapezoid.

Engineers can make changes to the design, checking on performance and suitability, then select the one that would be cheapest to construct at each specific site," says Clemmens who designed FLUME 3.0 at ARS' U.S. Water Conservation Laboratory.

The computer programming was done in cooperation with the International Institute for Land Reclamation and Improvement (ILRI) in The Netherlands.—By **Dennis Senft**, ARS.

*Albert J. Clemmens is at the USDA-ARS U.S. Water Conservation Laboratory, 4331 E. Broadway Road, Phoenix, AZ 85040; phone (602) 379-4356, fax (602) 379-4355.*

*FLUME 3.0 software and user's manual are available for \$37.00 through the ILRI, P.O. Box 45, 6700 AA, Wageningen, The Netherlands; or from Water Resources Publications, P.O. Box 260026, Highlands Ranch, CO 80126-0026, phone (800) 736-2405. ♦*

# MODWht3 for Modern Wheat Planning

**H**ow much wheat will my crop yield? How much residue will remain on the field after harvest? What would happen if I planted 2 weeks earlier?

Farmers will be able to answer these and many other questions with MODWht3, a new computer simulation developed by ARS researchers at Pendleton, Oregon. With just a few entries pertaining to a specific field, the simulation describes the day-to-day changes in a winter wheat crop, from germination through harvest-ripe grain.

As with its predecessor PLANT-EMP [See "Computerized Crystal Ball for Wheat Growth," *Agricultural Research*, July 1989, p. 15.], MODWht3 uses local weather data to predict crop characteristics. But MODWht3 is easier to use than the earlier version and is more powerful.

"It's like comparing roller skates to an automobile," says ARS soil scientist Ron Rickman, who worked on both models.

Most crop programs require the user to provide weather data in specific units and in a set format. For example, if the program uses temperature in degrees Celsius, it would not accept temperatures measured in Fahrenheit. The user would have to manually convert the temperatures before entering them into the program. With a few simple instructions, MODWht3 pulls the needed information from an existing weather file and performs all the conversions automatically.

The output is also flexible. The simulation provides values for any combination of over 100 variables, from the number of living stalks each day to total yield at harvest.

The key to this versatility is a modular design. MODWht3 contains six modules that describe the physical environment of the crop—soil, soil surface, atmosphere, root, shoot,

and canopy. A programmer could modify the simulation to describe corn instead of wheat by substituting the root, shoot, and canopy modules with information on corn. The soil, soil surface, and atmosphere modules would work the same for any crop.

Or a programmer could substitute one part of the program with a more sophisticated module. ARS researchers at the U.S. Salinity Laboratory in Riverside, California, are replacing its simple soil module with SOIL-CO<sub>2</sub>, a more complex soil model.

MODWht3's flexibility relies on a companion program, MODCROP. The two programs work together, like the human body and brain. MODCROP provides the autonomic functions, like breathing, and MODWht3 does the thinking.

Rickman and ARS mathematician Sue Waldman wrote both MODWht3 and MODCROP.

MODCROP contains all the standard processes necessary to run a computer simulation, also in a

modular format that can be modified. Usually programmers spend days rewriting this information for each new model. But just as a module of MODWht3 can be replaced, the entire MODWht3 program could be replaced with another crop management program. By using the existing commands in MODCROP, the programmer would save time.

The authors intend to publish the simulation in the American Society of Agronomy's new electronic journal. This will enable farmers, extension agents, educators, and programmers to download the complete package, including a user's manual and programmer's guide. The simulation runs under MSDOS on a personal computer with at least 640K of memory.—  
By **Kathryn Barry Stelljes**, ARS.

*Ronald Rickman and Sue Waldman are with the USDA-ARS Columbia Plateau Conservation Research Center, PO Box 370, Pendleton, OR 97801; phone (503) 278-3292, fax (503) 278-4188. ♦*

DOUG WILSON



MODWht3 can predict wheat yield even before heads appear on the stalks. (K3945-19)

# Science Update

## Producing Beef Cattle: Two Head Are Better Than One

Beef producers are closer to reaping benefits of an ARS project to increase production of twins from cows. Twins can lower beef production costs by almost a third. Currently, twins result from only about 1 percent of pregnancies in cows of popular breeds such as Hereford and Angus. But twin pregnancies of beef cows

KEITH WELLER



(K4323-2)

could start rising under a 5-year cooperative marketing agreement between ARS and American Breeders Service of DeForest, Wisconsin. The company will sell cattle semen and embryos with a high predicted breeding value for twinning. The cattle germplasm, from an experimental ARS herd, is the product of more than 12 years of ARS research on twinning. Scientists expect the herd's overall twinning rate—now 28 percent—will eventually exceed 40 percent. *Keith E. Gregory, USDA-ARS Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska; phone (402) 762-4176.*

## New Test Detects Lily Virus

The lily industry may soon use an ARS-developed test for faster, less costly, and more sensitive detection of a virus that reduces lily value. Bulbs infected with lily symptomless virus usually produce smaller lilies, and the industry operates a certification program for producing bulbs free of

the pathogen. But the new test detects the virus in bulb and plant samples that other methods deem virus free. It uses a technique called tissue blot immunoassay. *Hei-ti Hsu, USDA-ARS U.S. National Arboretum, Washington, DC; phone (301) 504-5657.*

## Ag Byproducts Could Clean Wastewater

What do soybean and rice hulls, rice bran, and sugar beet pulp have in common? All are inexpensive ag byproducts that bind to metals and other industrial wastes so they can be removed from water. Lab tests show the byproducts can be used only a few times in cleanup, because they break down rapidly. But the fast breakdown gives them an advantage over resins currently used in industry and wastewater treatment plants. While resins can be used repeatedly for nearly a year, their slow breakdown creates a disposal problem. *Joseph A. Laszlo, USDA-ARS Food Physical Chemistry Research Unit, Peoria, Illinois; phone (309) 681-6322.*

## Catch More Rain, Grow More Cotton in the Rye

Cotton yields increased in a 2-year test in the southeastern Coastal Plain, thanks to a winter cover crop of rye and minimal plowing. When rain fell during the cotton growing season, surface mulch from the rye held more moisture in the sandy Coastal Plains soil. As a result, lint yield averaged 293 pounds an acre higher than under the usual practice—leaving cottonfields fallow over winter. *Philip J. Bauer, USDA-ARS Coastal Plain Soil, Water, and Plant Conservation Research Unit, Florence, South Carolina; phone (803) 669-5203.*

## New Partnership Addresses Chemical Spray Drift

Federal officials and industry have entered into a cooperative R&D agreement to assess and reduce farm chemical drift. The partnership, aimed at safeguarding the environment as well as agricultural workers, includes USDA, the U.S. Environmental Protection Agency, and an industry consortium—the Spray Drift Task Force. As part of the agreement, ARS laboratories in College Station, Texas; Wooster, Ohio; and Stoneville, Mississippi, will work to improve equipment and techniques for aerial and ground chemical application and to improve spray techniques for orchards and horticultural and landscape crops. *Richard M. Parry, USDA-ARS Deputy Assistant Administrator, Beltsville, Maryland; phone (301) 504-5734.*

## New Kenaf Shrugs Off Root Pest

In fields infested by root-knot nematodes, a kenaf strain called SF459 can yield three times as much fiber as standard kenaf varieties. Nematodes are the major pests hindering efforts to turn kenaf into an important annual fiber crop in the United States. Chemical nematicides are not economically feasible or environmentally desirable. U.S. kenaf could replace costlier, less environmentally friendly ways to make many products such as packing material, chemical-spill cleanup products, and a range of recyclable paper goods including newsprint and high-quality paper. Currently, kenaf is grown on only 4,000 acres in this country—compared to 600,000 in China. A commercial variety of nematode-tolerant kenaf based on SF459 may be available next year. *Charles G. Cook, USDA-ARS Conservation and Production Systems Research, Weslaco, Texas; phone (210) 969-4812.*

👉 The dusky sap beetle has been duped into delivering deadly *Bacillus subtilis* bacterium to the fungus that causes aflatoxin contamination in corn.